Environment and Labour

Environmental and Natural Areas Management

Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 1

Form a Source Water Protection Advisory Committee

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Step 1

Form a Source Water Protection Advisory Committee

Designing Plans For Source Water Protection In Nova Scotia

A Drinking Water Strategy For Nova Scotia describes a multiple-barrier approach to clean, safe drinking water for Nova Scotians. The first line of defence in this multiple-barrier approach is to keep clean water clean. This booklet series describes how water utilities and municipalities can do that. It guides you through the process of developing a source water protection plan for your municipal water supply.

To keep clean water clean, we must protect the source water supply area. This guide describes **Step One** in the process recommended by Nova Scotia Environment and Labour (NSEL) for developing a source water protection plan: Form a Source Water Protection Advisory Committee. The committee is an effective way of getting input and advice from stakeholders. A well-formed committee will mean better relations with customers and other stakeholders.

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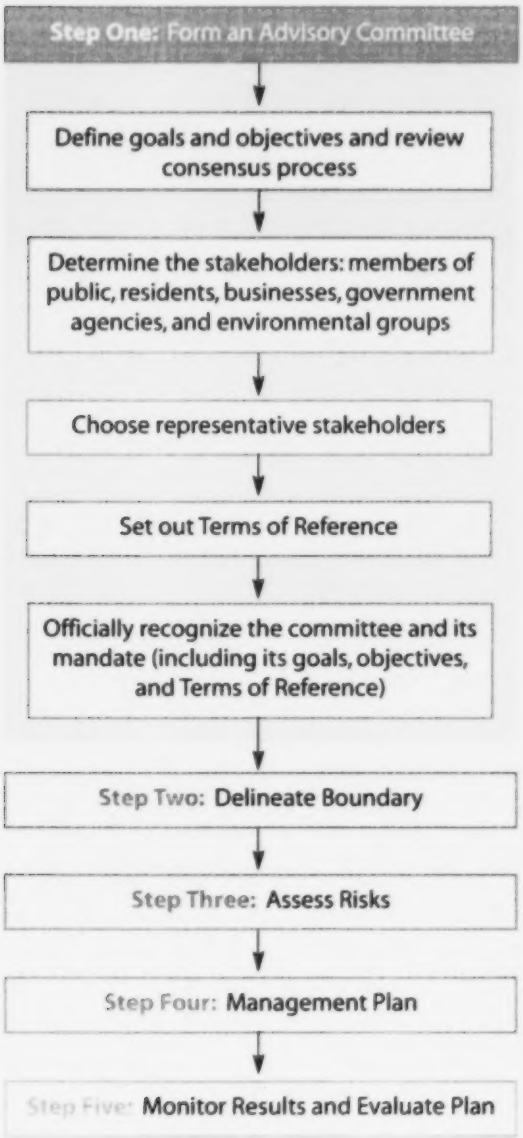
Step One Flow Chart

These are the five recommended steps for developing a municipal source water protection plan, and the actions that should be used to form an advisory committee:


Step One: Form an Advisory Committee
Define goals and objectives and review consensus process
Determine the stakeholders: members of public, residents, businesses, government agencies, and environmental groups
Choose representative stakeholders
Set out Terms of Reference
Officially recognize the committee and its mandate (including its goals, objectives, and Terms of Reference)
Step Two: Delineate Boundary
Step Three: Assess Risks
Step Four: Management Plan
Step Five: Monitor Results and Evaluate Plan

The Importance of Forming a Source Water Protection Advisory Committee

A strong commitment is required at the local level, because source water protection (SWP) employs a combination of management approaches that should be developed in conjunction with community stakeholders. The process should be consensus-driven and contingent on the collaboration of all stakeholders. The communities will be able to carry out mutually beneficial, locally developed and administered SWP programs that achieve the long-term goal of providing high quality drinking water through the cooperation of multiple stakeholders.

The first and most important step in developing a SWP plan is to form a fully representative Advisory Committee. The water utility or municipality should set up the advisory committee, and should champion source water protection. A strong advisory committee will facilitate greatly the development of a source water protection plan and will help to keep the plan focused on its objectives. The composition of the advisory committee should reflect the jurisdictions the supply serves.

The consensus-based approach to addressing issues that relate to water quality must be clearly understood by the advisory committee. They must also clearly understand their roles and responsibilities. Consequently, the mandate of the advisory committee must be clearly defined, including roles of the committee members, their responsibilities, whom they report to, and the length of term. Advice on the composition of the advisory committee, and clarification of the roles and responsibilities of the committee can be provided by Nova Scotia Environment and Labour (NSEL).

Understanding the Consensus-Based Approach

In a consensus process, representatives of all the necessary interests that have a stake in an issue work together to find a mutually acceptable solution. Successful consensus processes follow several guiding principles:

Consensus decision-making - Participants make decisions by agreement rather than by majority vote.

Inclusiveness - All necessary interests are represented or, at a minimum, approve of the discussions.

Accountability - Participants usually represent stakeholder groups or interests. They are accountable both to their constituents and to the process.

Flexibility - Participants design a process and address the issues in a manner they determine most suitable to the situation.

Shared control - Participants share responsibility for setting the ground rules for a process and for creating outcomes.

Commitment to implementation - The sponsor and all stakeholder groups commit to carrying out their agreement.

When groups are engaging in problem-solving discussions, it is important to exchange information, frame issues, generate and evaluate options, develop mutually acceptable solutions, and secure the endorsement of all constituents and authorized decision-makers. The water utility or municipality retains final decision-making authority, but in a consensus process the utility or municipality puts the product of a consensus process out for official review as the proposed decision.

Consensus in the public policy setting occurs when:

- the parties have reached a meeting of the minds sufficient to make a decision and carry it out, or
- no one who could block or obstruct the decision or its implementation will exercise that power, or
- everyone needed to support the decision and put it into effect will do so

Given the mixture of issues and values in source water protection, the resulting agreement will be met with varying levels of enthusiasm and support for different components, but on balance will be one that each party or stakeholder can accept.

Information adapted from the Government of Maine website at <www.maine.gov/consensus/ppcm/background.html> and the Canadian Council of Ministers of the Environment website at <www.ccme.ca/about/consensus.html>

Forming a Source Water Protection Advisory Committee

The water supply owner, which may be the water utility or municipality, initiates the formation of the advisory committee. The first action in this step is to define goals and objectives for the committee. The goals and objectives will help determine the mandate of the committee. This is essential since it will help keep the committee focused and will allow the utility or municipality to evaluate the functioning of the committee (for potential goals and objectives, please see the example on page 4). It is then necessary to find out who will be most affected by the source water protection plan. Representatives from affected groups should be included to ensure all concerns are addressed early in the planning process. Representation on the committee will vary considerably, depending on the nature of the source water area, but should include government representatives and stakeholders (for potential committee members, please see Table 1). NSEL can provide input into the composition of the committee and advise on roles and responsibilities.

Table 1 - Potential Committee Members

Stakeholders	Government
- Agriculture - Retailers - Environmental groups - Forestry - Industry - Land owners - Community associations - Recreational interests	- Municipal Councillors - Water Utility Engineers - Municipal Planners - Environment and Labour - Natural Resources - Transportation and Public Works - Agriculture and Fisheries - Department of Fisheries and Oceans (Federal) - Service Nova Scotia and Municipal Relations - Department of Health

If the source water area is located outside of the jurisdiction that it is supplying, then both jurisdictions must be involved (e.g. a town's supply is located outside the town limits in the county's or municipality's jurisdiction). This will enable the group withdrawing the water to work cooperatively with residents and businesses in the source water supply area.

It is important to develop good working relations between committee members and to ensure the chair of the committee communicates effectively and openly with all members from the beginning of the planning process. Conflicts can be prevented when the consensus-based approach is used for decision-making. The consensus-based approach requires an understanding by all members that opinions must be respected and compromises may be required to achieve the overall goal — to provide clean, safe drinking water to Nova Scotians.

If the committee cannot come to consensus on an issue then the municipality or water utility may need to use a professional facilitator to help the process. NSEL can provide guidance on selecting an appropriate facilitator. However, well-defined Terms of Reference can improve the functioning of the committee. The utility is responsible for working with stakeholders to draft the Terms of Reference that provide "ground rules" for the advisory committee. Committee members must agree to work with the process laid out in the Terms of Reference, and council must agree to accept the recommended source water protection plan developed by the consensus-driven committee process. Also, depending on the challenges and time required to organize the committee and develop the source water protection plan, there may be a need to use additional staff or consultants.

Example of How to Set Up a Source Water Protection Advisory Committee

The following is a list of questions that the utility or municipality should answer while setting up their advisory committee and provides examples of who to include in a source water protection advisory committee. The membership of a committee will vary from location to location and will depend on the makeup of each community.

A. What should the goals and objectives of the committee be?
The municipality or utility should identify goals and objectives for their SWP Advisory Committee, for example:

Goal: To develop a source water protection plan and provide the municipality or utility with advice on matters concerning land-use issues, as well as water quality, levels and flows in the Source Water Protection Area.

Objectives: To provide advice to the municipality or utility: 1) that will attempt to satisfy the water quality and quantity concerns of all stakeholder groups; 2) about the sources of contamination in the source water supply area; 3) about the management options available; and 4) about the success of the protection plan.

B. Who will be most affected by the source water protection plan and could provide useful information?
The municipality or utility should determine what stakeholders would be most affected by the SWP Plan. For example, this could include land owners surrounding the water source, subdivision residents, cottage associations and/or owners, forested-land owners, tree-harvesting companies, and farm owners.

C. What local, provincial, and federal agencies will provide useful information?
This could include municipal governments, NSEL, Transportation and Public Works (TPW), Agriculture and Fisheries (DAF), Health and the federal Department of Fisheries and Oceans (DFO).

D. Are any environmental groups located near or within the source water protection area that may be affected?

E. Who should represent groups listed in questions B-D?
The municipality or utility should choose representatives for their committee from the stakeholders identified in questions B through D.

F. Define Terms of Reference for Committee
The utility or municipality, in consultation with the advisory committee, should form Terms of Reference for the advisory committee. For example:

These Terms of Reference shall serve to constitute the Source Water Protection Advisory Committee as an advisory group to the Town of X and its Utility, the Municipality of the County of Y, and the communities in the area. It will address problems and solutions to matters concerning land-use issues, as well as water quality, levels and flows in the SWP Area.

Mandate
The committee will report to the Utility, and be recognized by the Town of X, the County of Y, and the Utility. Members will be appointed by the Utility, in consultation with the Town and the County.

General

1. The Committee will review and make recommendations on all activities affecting the SWP area as requested by the Utility, Town of X, Municipality of the County of Y, and communities in the area.

2. The Committee may from time to time request individuals or groups to make representation to the committee on matters affecting the SWP area.

3. The Committee will review and comment on water quality and quantity monitoring programs and other studies related to the SWP area. All water quality information available from member agencies shall be made available to the Committee.

4. The Committee will liaise with government agencies not represented on the Committee with regard to matters affecting the SWP area; particularly the Departments of Environment and Labour, Health, and Fisheries and Oceans.

5. The Committee will develop information and education programs about source water protection for local residents, land owners and other users of the SWP area lands.

6. The Committee will elect a chair and vice-chair.

Membership

1. Membership will consist of:

   - at least two members of the public, preferably owners of land within the SWP area
   - a local representative from each of the agriculture and forestry sectors
   - one technical representative from each of the following organizations:
     - Town of X
     - County of Y
     - DNR & TPW
   - one member of the Town Council
   - one member of the County Council

Operation of the Committee

1. The Chair and vice-chair of the Committee are appointed annually by the membership at the meeting closest to 1 April. Members will serve on the Committee for at least one year, after which the Utility may choose an alternate for their respective position on a yearly basis at the meeting closest to 1 April.

2. The Town of X will provide secretarial services.

3. The Committee will endeavour to conduct business by consensus, but should the Committee be unable to attain consensual agreement on an issue, then the Utility may appoint a facilitator. Should this process fail, voting may be necessary. All motions require support from at least two-thirds majority of the members present. Six members will constitute a quorum.

4. The Committee will meet as necessary, but no less than three times a year.

5. The Utility may amend the Terms of Reference, in consultation with the Town and the County, from time to time.

6. The Committee must prepare an annual report of its activities to be distributed to all bodies represented on the Committee and to other interested parties.

7. The Chair will act as the Committee spokesperson.

8. The Committee may call for the input of other land owners in the source water supply area from time to time.

Final Products

If a utility or municipality uses the information provided in this document, it should be able to produce the following final products:

- A source water protection advisory committee that is composed of representatives of all stakeholders in the source water protection area
- A source water protection advisory committee whose mandate is defined through its Terms of Reference and constituted by the utility and/or municipality

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Glossary

Source water protecti
The portion of the sourc
will be covered by the s
protection plan.

Surface water supply
The area of the watersh
water that is used to sup
the source. Surface wat
a lake, river or stream.

Groundwater supply
The land area that contr
community well, also k

Watershed
The area drained by or
lake, or other body of w
described as the geogra
within the confines of a
way to think about wha
represents is to conside
placed a small amount
would settle at the bott
at the bottom of the bo
the bowl represents the
pour water onto any pa
eventually land at the b
lake. However, if you p
bowl (i.e. on the other s
will flow somewhere el
can also be thought of

Groundwater
Water naturally occurri
the earth. It is water in
in an aquifer from whic
groundwater runoff are

Aquifer
A geological formation
or part of a formation t
saturated permeable ma
quantities of water to w
water-bearing stratum
has sufficient porosity
ample supplies of grou
wells or springs.

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Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 2

Delineate a Source Water Protection Area Boundary

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Designing Plans For Source Water Protection In Nova Scotia

A Drinking Water Strategy For Nova Scotia describes a multiple-barrier approach to clean, safe drinking water for Nova Scotians. The first line of defence in this multiple-barrier approach is to keep clean water clean. This booklet series describes how water utilities and municipalities can do that. It guides you through the process of developing a source water protection plan for your municipal water supply.

To keep clean water clean, we must protect the drinking water supply area. This guide describes **Step Two** in the process recommended by Nova Scotia Environment and Labour (NSEL) for developing a source water protection plan: Delineate a Source Water Protection Area Boundary. This booklet will provide detailed technical information on recommended delineation procedures. During **Step Two,** the advisory committee may solicit public input in order to ensure that there are no gaps in the information that describes the source water protection area.

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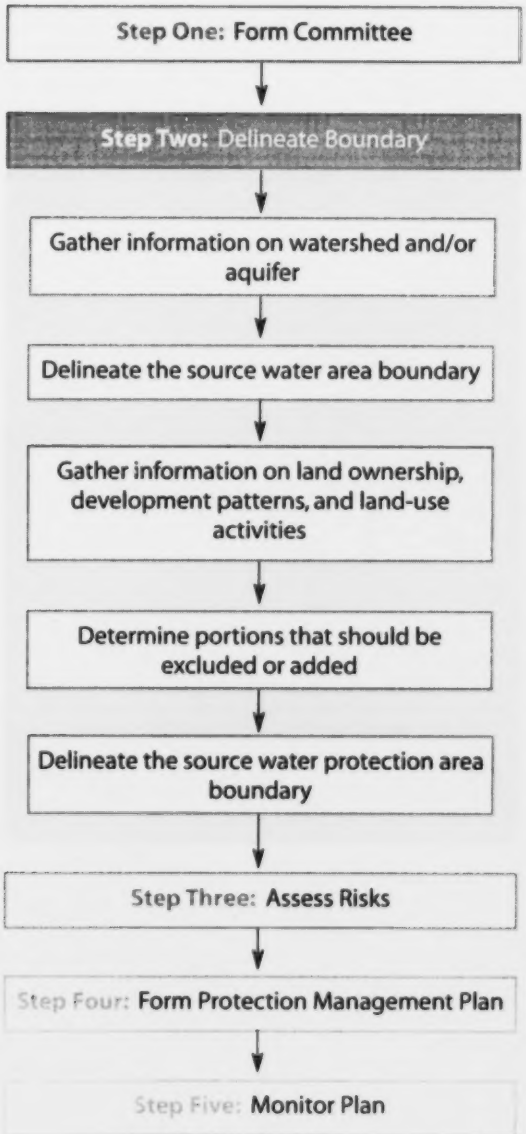
Step Two Flow Chart

The following identifies the five recommended steps for developing a municipal source water protection (SWP) plan, and lists the actions that should be used to delineate a SWP Area, whether it is surface water, groundwater, or Groundwater Under the Direct Influence of surface water (GUDI).


Step One: Form Committee
Step Two: Delineate Boundary
Gather information on watershed and/or aquifer
Delineate the source water area boundary
Gather information on land ownership, development patterns, and land-use activities
Determine portions that should be excluded or added
Delineate the source water protection area boundary
Step Three: Assess Risks
Step Four: Form Protection Management Plan
Step Five: Monitor Plan

Importance of Delineating the Source Water Protection (SWP) Area Boundary

It is important to define or delineate your SWP Area boundary for the following reasons:

- You will know exactly what land area you will be dealing with, and, therefore the hydrogeological, ecological and hydrological factors that interact with the source water.
- It will help you determine what land owners will be affected by your protection plan, and what activities and land-uses you must concentrate on in your protection plan.

By clearly identifying what area supplies water to your source, you will be better able to provide adequate protection for it. However, if you do not clearly identify the boundary, there is a risk that a source or potential source of contamination may be over-looked in the protection planning process. Therefore, the utility or municipality should properly delineate the boundary to improve its confidence in the plan.

Before you begin the delineation process, it is important to understand the different types of source water. To begin with, **source water** is untreated water from streams, rivers, lakes, or underground aquifers, which is used to supply private wells and public drinking water. It can be divided into two types: 1) Surface water; and 2) Groundwater.

Surface water sources include lakes, rivers, streams, and ponds.

Groundwater is obtained from an aquifer through a drilled or dug well.

Although there are two types of source water, the two are often interlinked. Most rivers and lakes are fed by groundwater. Groundwater wells located near surface water bodies, or that are poorly constructed or "leaky," may be affected by surface water.

This document is divided into two parts: A) How to delineate a *surface* source water protection area; and B) How to delineate a *groundwater* source water protection area.

Several terms will be used throughout the remainder of the document that you should familiarize yourself with, and their definitions are located in the glossary at the end of this document.

Detailed Information on Each of the Actions
Once you have determined the type of source water you have, go to the appropriate section below (A: Surface Water or B: Groundwater). After you have completed the delineation of the boundary of the Source Water Protection Area, it may be submitted to NSEL for review and comments.

Source Water Protection Area Delineation

A) Surface Water

To protect a surface water supply, you must delineate the area that contributes water to the surface water body so that potential sources of contamination can be identified and managed. The following steps explain how to do this:

Gather information on physical aspects of source water area
The physical aspects that are important to define or delineate the surface water source water area boundary include the topography and location of surface water bodies (streams, rivers, lakes and wetlands). Maps of the local bedrock and soil geology or hydrogeological studies, if available, may also aid in this work.

Delineate the boundary of source water area
The most commonly used method to delineate a surface source water area is with topographical maps and aerial photographs (viewed through stereoscopes). A line is used to connect high elevation points around the water body. This is usually done by a knowledgeable technician.

To delineate the boundary from a topographic map or air photo, start at the outlet of the lake (usually a stream), or at the location of the chosen stream cross-section (most likely the water withdrawal point). Then draw the line away from the left or right stream bank, being sure to maintain the line at right angles to the contour lines (i.e. going up-slope). The line should stop at the watershed divide. Continue the line until its trend is generally opposite to the direction in which it began and is generally above the head/source waters of the lake or stream. Then return to the starting point and draw the boundary from the other bank, eventually connecting with the first line.

Frequent visual inspection of the contour pattern is required as the boundary is traced out to ensure an imaginary drop of water on the stream side of the divide (or inside the bowl) would flow downhill and eventually reach the lake or outlet. A boundary can never cross a stream. The lowest point in a watershed is always the outlet—that is, the starting point for the delineation.

It is also possible to use computers to do this more quickly, and the results are in a more useful format. Using a computer and a Geographic Information System (GIS) a knowledgeable technician can easily produce a map of the source water area boundary and can also show other relevant information on the same map, such as surface water bodies, existing water monitoring stations, and land-use patterns.

Whether you are using hard copy or a computer-based copy of a topographical map, it is recommended that you use information at a scale of at least 1:50,000, with a preferred scale of 1:10,000. Some mapping is available at Service Nova Scotia and Municipal Relations' Land Information Offices.

Gather information on land ownership, development patterns, and land-use activities

Once your source water area boundary is drawn on a map you should form a separate map that also shows land ownership, land-use activities, and, if available, municipal zoning information. This will help you determine if you should alter your source water area boundary in a way that will make management of the area more successful.

The Source Water Protection Advisory Committee may, in consultation with the utility or municipality, solicit public input at this point to gather further information on land ownership and land-use activities in the source water area.

The purpose of delineating the SWP Area is to determine the land area where potential contaminant sources should be identified and management options should be considered to reduce risks to the source water. Further information about identifying potential contaminant sources and possible management options is provided in booklets **Three** and **Four** of our series on **Developing a Municipal Source Water Protection Plan.**

Determine any portions of the source water area that should be excluded from or added to the source water protection area

Although your source water protection plan should cover the entire source area, you may decide to remove some portions of it or extend the boundary to cover some areas outside it. This will need to be determined by the utility or municipality in consultation with the SWP Advisory Committee and affected land owners on a case by case basis.

An example of a situation where this may occur is a land owner who has 80% of their land within the source water area. After consultation with the land owner, it may be decided to include the entire property in the SWP Area for the sake of easier management. However, if the land owner is uncooperative it may not be worth the effort required to include the land outside the source water area. You may also want to add a property to your SWP Area if it is a potential source of contamination, such as an industrial factory just outside of your source water area.

An example of a situation where it may be necessary to remove a portion of the source water area from the source water protection area would be a land owner who lives along the uppermost boundary of the watershed (the watershed divide). The source water area in this example is very large, and the portion of the land owner's property that is within it is only 1/2 hectare. In this case, it may be preferable to remove the property from the source water protection area.

Delineate the boundary of the source water protection area

From the information gathered in the previous sections it is now possible to form a map showing the area that will be covered by the source water protection plan (i.e. the source water protection area).

B) Groundwater

To protect a groundwater supply, you must delineate the area that contributes water to the well so that potential sources of contamination can be identified and managed. The source water protection area surrounding the well or well field where groundwater is to be protected is called the wellhead protection area (WHPA). The protection area includes all or part of the of the area that contributes groundwater to the well field and is typically divided into several smaller zones that are used to manage different types of contaminants. Delineating the protection area is usually done using mathematical or computer models that use site-specific hydrogeological data. This is the most technical step in the wellhead protection planning process. The advisory committee will probably need professional assistance from a hydrogeologist to complete this work.

Identify Wellhead Protection Zones[1]

The WHPA is divided into zones based on the time it takes groundwater to travel to the well. The different zones reflect the fact that different types of contaminants in groundwater will persist for different lengths of time, migrate at different rates and pose different health risks. Zones that are closer to the well require a higher level of protection because there is a shorter distance to travel before groundwater reaches the well and, therefore, less time to respond to contamination events and less opportunity for contaminants to be diluted or removed by the aquifer. Usually the WHPA is divided into two-year, five-year and twenty-five-year time of travel (TOT) areas. The two-year TOT area is closest to the well; the five and twenty-five-year is furthest away.

In Nova Scotia, a minimum of three WHPA zones are recommended. These zones are defined based on the groundwater travel time, as follows:

- **Zone 1** – 0 to 2 year travel time. This zone is used to protect against microbial contaminants (e.g., bacteria and viruses) and chemical contaminants.
- **Zone 2** – 2 to 5 year travel time. This zone is used to protect against all chemical contaminants (e.g., petroleum contaminants and persistent, mobile contaminants).
- **Zone 3** – 5 to 25 year travel time. This zone is used to protect against persistent, mobile chemical contaminants (e.g., chlorinated solvents, nitrates, etc.).

In addition to the zones defined above, identify a "well site control zone" to protect the area immediately surrounding the well. This area, which is considered to be the wellhead itself, is used to protect against the day-to-day activities of the water utility and any other potential sources of contamination, including vandalism. The well site control zone can be determined based on a simple fixed radius, which should be a minimum of 30m.

The purpose of delineating the WHPA zones described above is to determine the land area where potential contaminant sources should be identified and management options should be considered to reduce risks to the well field. The Source Water Protection Advisory Committee may solicit public input at this point to gather further information on land ownership and land-use activities in the WHPA. Further information about identifying potential contaminant sources and possible management options is provided in booklets **Three** and **Four** of this series.

The use of WHPA zones is an industry standard and is commonly used in other provinces, including New Brunswick, Ontario, and British Columbia. Although these are the recommended WHPA zones for Nova Scotia, the advisory committee may choose to use larger zones to provide added protection. For example, the WHPA may be expanded to include the entire watershed, entire zone of contribution, indirect recharge areas, or areas where the aquifer is expected to be particularly vulnerable to contamination, such as

[1] Information has been adapted from the Government of British Columbia's document "Step Two - Define the Well Protection Area"

where fractured bedrock is exposed at ground surface. The most important area to protect is Zone 1. If the protection of Zone 2 and/or 3 is not practical and prevents the protection of Zone 1, then it may be necessary to focus your efforts on Zone 1 before proceeding to Zones 2 and 3. NSEL should be consulted before this decision is made.

Wells that have been classified as Groundwater Under the Direct Influence of surface water (GUDI) are considered surface water sources for the purposes of both source water protection and water treatment requirements. This means the Surface Water Treatment Standard applies to GUDI wells. For GUDI wells, there is potential for contaminants within the watershed to be rapidly carried to the well field by surface water, even if the contaminant sources are outside the 2-, 5-, or 25-year groundwater travel times. Therefore, the land area within the watershed boundaries also should be included within the WHPA. This approach ensures that the potential risk of contaminants migrating in surface water adjacent to a well field will be considered in the source water protection plan. Because groundwater outside the watershed may also contribute water to the well field, the WHPA Zones 1, 2, and 3 should still be delineated for GUDI wells.

Methods to Delineate the Wellhead Protection Area

It is important to define the WHPA accurately. Contaminants in the WHPA could pollute the source water. There are several methods to determine the WHPA, of which some are complex and technical. The five methods most commonly used to delineate WHPA's are

- Arbitrary Fixed Radius (AFR)
- Calculated Fixed Radius (CFR)
- Analytical equations
- Hydrogeologic Mapping
- Numerical Modeling (recommended)

Each of the methods listed above is described in Appendix A.

The preferred method for delineating wellhead protection areas in Nova Scotia is numerical modeling, which uses a computer model. When properly set up and calibrated with adequate field data, computed models provide the best method to accurately delineate the source water protection area.

Calculate the WHPA Zones

How do you decide which of the five methods to use? Some of the advantages and disadvantages are listed on the table on the next page. Although it is tempting to use simple and less expensive models (such as AFR), they are based on very simplistic assumptions. These assumptions may not apply in your situation, and could result in the planning team wasting resources on protection measures in an area that contributes little or no water to the groundwater supply. Experience in the United States shows that people may challenge your defined WHPA, because of the cost of implementing protection measures, and you must be able to justify your decisions.

However, AFR and CFR may be useful as interim methods to allow well protection planning to get underway. Once the community sees the value of groundwater protection and supports it, you may find additional funding to refine the WHPA using more accurate methods. You should attempt to delineate the WHPA as accurately as possible, based on the information and funding available, local conditions and size of the water system. For example, if your community is tapping a well in a sand and gravel aquifer where the geology is relatively simple and the water system has over 100 connections, then it may be appropriate to use analytical equations. However, you may choose to use methods that are more accurate, such as hydrogeologic mapping or numerical modeling, especially in populated areas where the WHPA boundary may need to be pinpointed more accurately. Technical advice on which method to use is available from the NSEL or groundwater consultants.

Gather Information and Conduct Analysis
In order to define the WHPA, it is necessary to collect available information on each community well and on the groundwater resources in the local region. Much of this information may already exist.

Seek Technical Expertise
Do you need to hire a groundwater consultant to help delineate the WHPA? As a rule, where the delineation involves methods other than AFR and CFR, it is recommended that a groundwater consultant is hired to assist in this work.

The following series of questions may provide some guidance:

- Is your community well in a fractured bedrock aquifer?
- Is there more than one well in the system, and are they located close to each other (e.g. less than 100 metres)?
- Is your community well supplying a significant number of customers (greater than 25 connections)?
- Are the local hydrogeologic conditions complex?

If your answer to any of these is yes, hiring a groundwater consultant to assist in delineating the WHPA is a good idea.

You will almost certainly need professional assistance if your aquifer is in fractured bedrock. Groundwater flow in many bedrock aquifers occurs through discrete fractures or through discrete zones, and flow in these aquifers is usually hard to predict. Therefore, capture zones for wells drilled in fractured bedrock aquifers require more data and greater hydrogeologic expertise to analyze. It is likely that hydrogeologic mapping or numerical modeling methods will be needed to delineate the WHPA.

Final Product

The information provided in this document is intended to provide a utility or municipality with sufficient information so that they are able to produce the following final product: Delineation of the Source Water Protection Area Boundary based on scientifically established data and criteria.

For More Information

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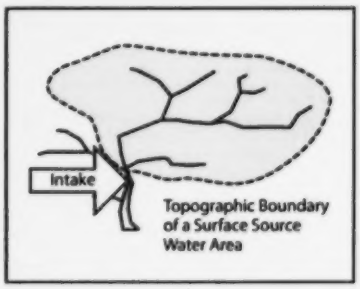
Web address: www.gov.ns.ca/snsmr/

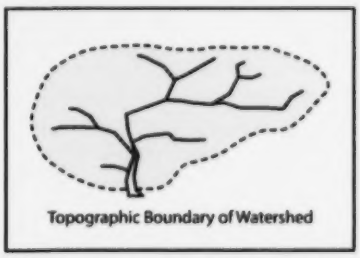
Source Water Protection (SWP) Area
The portion of the source water area that will be covered by the source water protection plan.

Source Water Area
The area of the watershed or wellhead that contributes all the water that is used to supply drinking water from the source.



Surface Water

Watershed



The area drained by, or contributing to a stream, lake or other body of water. It is the area that topographically appears to contribute all the water that passes through a given cross-section of a stream. Topography is the change in height of land relative to sea level.

Another way to think about what a watershed boundary represents is to consider a soup bowl. If you placed a small amount of water in the bowl it would settle at the bottom of the bowl. The water at the bottom of the bowl represents a lake, and the bowl represents the lake's watershed. If you pour water onto any part of the bowl it will eventually land at the bottom of the bowl, or in the lake. However, if you pour water outside of the bowl (i.e. on the other side of the bowl's lip) it will flow somewhere else. Therefore the bowl's lip can also be thought of as the watershed boundary.

Groundwater

Groundwater Source Water Protection (SWP) area or Wellhead Protection Area (WHPA)
The land area on which groundwater protection measures are taken.

Well field
The land area around a pumping well or group of pumping wells.

Time of Travel (TOT)
The wellhead protection area can be divided into sub-areas based on "time of travel": the time it takes water to flow from a given point to the well.

Zone of Contribution
The area of the aquifer that recharges the well.

GUDI
GUDI stands for Groundwater Under the Direct Influence of surface water. It is defined as any water beneath the surface of the ground with:

- significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as *Giardia lamblia* or *Crytosporidium*; or
- significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.

Aquitard
An underground geological formation that is only slightly permeable and yields inappreciable amounts of water when compared to an aquifer. Aquitards essentially block the flow of water.

Isopach
A line on a map connecting points below which a particular rock stratum has the same thickness.

Evapotranspiration
The return of water vapour to the atmosphere by evaporation from land and water surfaces and by the transpiration of vegetation.

APPENDIX A

Detailed methodologies for WHPA Delineation[1]

This information is meant to give a general understanding of the five different methods used to delineate a WHPA. This information should be used to decide which method is best for your situation. Although NSEL recommends method five, there may be other factors that a utility or municipality needs to consider (such as financial resources). Careful consideration should be given to the consequences of choosing a method other than method five.

1 & 2. Arbitrary Fixed Radius and Calculated Fixed Radius

Both the Arbitrary Fixed Radius (AFR) and Calculated Fixed Radius (CFR) methods define the capture zone by drawing a circle around the well. The difference between the two methods is that the circular AFR area is based solely on a fixed distance from the well, while the area for the CFR is calculated using the volume of water pumped.

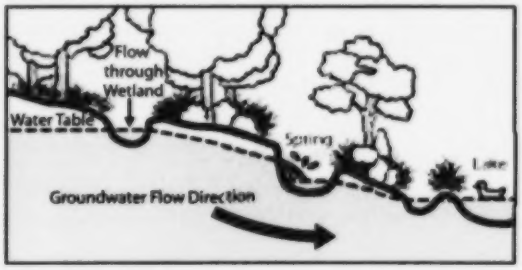
The AFR usually covers the area within 300 metres of the well. This WHPA covers land beyond the immediate area of the well, but is not so large that protection of the source area becomes too difficult. Major disadvantages of this method are that it is arbitrary, and the circular area cannot be subdivided into time of travel areas. The AFR should be used as a temporary measure and only where no information exists on the well, water use, or the aquifer.

The CFR calculates a circular area based on the volume of water pumped by the well over a specified period of time (e.g. two, five or twenty-five years). This reflects the time it takes a contaminant to travel from the CFR boundary to the well, based on the pumping rate. The CFR method is suitable for sand and gravel aquifers, where the water table is relatively level and wells supply no more than 100 connections.

3. Analytical Equations

If the water table slopes, the fixed radius methods do not work. The shape of the WHPA around the pumping well is not circular, as recharge to the well comes from "up-gradient" and has a long, finger-like shape.

Simple equations have been developed for delineating WHPAs where the water table slopes. Analytical equations are suitable for sand and gravel aquifers where conditions are uniform and there is sufficient information on the pumping rate, aquifer transmissivity, and water table slope. This method may not work well for fractured bedrock aquifers.

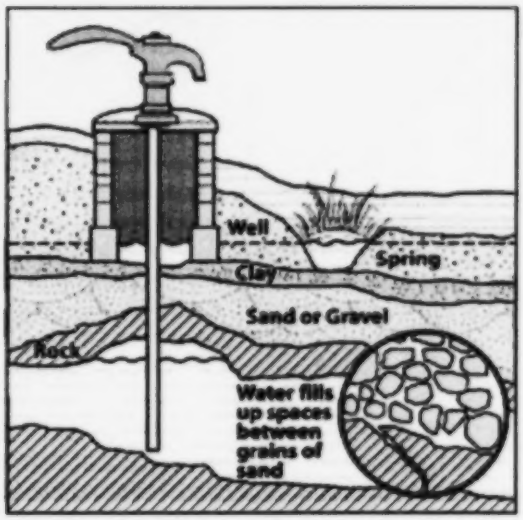


[1] Adapted from the Government of British Columbia's document "Step Two - Define the Well Protection Area".

4. Hydrogeologic Mapping

Hydrogeologic mapping locates and maps the groundwater flow. The WHPA is defined by identifying the aquifers and aquitards, mapping the groundwater levels, and then determining flow directions from water level contours. This method requires considerable expertise and should be carried out with the assistance of a professional hydrogeologist.

This method is particularly suitable for shallow sand and gravel aquifers where ambient groundwater flow directions can be directly implied from topography and where the surface geology can be used to identify aquifer boundaries.



Recommended Method:

5. Numerical Modeling

Numerical modeling develops and uses computer models of the groundwater flow system. The computer model most commonly used is MODFLOW. Information on the hydrogeology of the area is entered into a computer program, which calculates the water level, flow rates, and flow directions. This information is used to define the WHPA and time of travel of the contaminants.

The modeling exercise must be properly documented so that users and reviewers of the model results can understand the assumptions and limitations of the model. The model documentation should include a description of the purpose of the model, formulation of the conceptual model, boundary and initial conditions, aquifer parameters, the grid of the numerical model with locations of boundaries and internal source and sinks, calibration and sensitivity analyses, and results of predictive simulations.

The main advantage of numerical modeling is that it can combine variations in hydrogeology and pumping conditions that analytical equations and other simpler methods cannot. However, considerable amounts of data, technical expertise, and interpretation are required to develop a numerical model. It is also a relatively costly technique to use. Professional assistance will be needed.

Developing a numerical model requires large amounts of data, so it may not be practical to develop models for areas of the province where data are scarce. However, the capabilities of models make them a valuable tool for on-going resource management and contingency planning. For larger communities with good data and the resources to develop and maintain a computer model, this type of model is an excellent long-term investment.

Data requirements for groundwater flow models.

A. Physical framework

1. Geologic map and cross sections showing the areal and vertical extent and boundaries of the system.
2. Topographic map showing surface water bodies and divides.
3. Contour maps showing the elevation of the base of the aquifers and confining beds.
4. Isopach maps showing the thickness of aquifers and confining beds.
5. Maps showing the extent and thickness of stream and lake sediments.

B. Hydrogeologic framework

1. Water table and potentiometric maps for all aquifers.
2. Hydrographs of groundwater head and surface water levels and discharge rates.
3. Maps and cross sections showing the hydraulic conductivity and/or transmissivity distribution.
4. Maps and cross-sections showing the storage properties of the aquifers and confining beds.
5. Hydraulic conductivity values and their distribution for stream and lake sediments.
6. Spatial and temporal distribution of rates of evapotranspiration; groundwater recharge; surface water-groundwater interaction, groundwater pumping, and natural groundwater discharge.

Adapted from Anderson and Woessner, 1992.

METHOD	EXPLANATION
Arbitrary Fixed Radius	Assign circular area of fixed radius (300 m) around well
Calculated Fixed Radius	Calculate cylindrical volume of aquifer supplying water to well for a given pumping rate and time period
Analytical Equations	Calculate source water protection area dimensions using analytical equations accounting for uniform ambient flow
Hydrogeologic Mapping	Map source water protection area from measured groundwater level contours and geomorphologic, topographic and hydrologic features
Numerical Modeling	Delineate source water protection area using numerical flow modeling incorporating actual hydrogeologic information

ASSUMPTIONS	TYPICAL DATA REQUIRED	ADVANTAGES/ DISADVANTAGES	WHEN APPLICABLE
• Uniform aquifer • Negligible ambient flow	None	• Easy and inexpensive to apply • Arbitrary • May be difficult to defend	Inadequate information on well construction, pumping rate and hydrogeology; typically used for drive points and dug wells
• Uniform aquifer • Negligible ambient flow	• Pumping rate and/or water use • Aquifer thickness • Aquifer porosity	• Easy and inexpensive to apply • Accounts for some site-specific information • Based on simple physical equations	Well construction and pumping rate are known, hydraulic gradient is low and aquifer thickness can be estimated; not appropriate for fractured bedrock aquifers
• Uniform aquifer • Horizontal, steady-state flow • Uniform ambient flow • Capture zone does not extend beyond watershed divide	• Pumping rate and/or water use • Aquifer transmissivity • Ambient hydraulic gradient • Aquifer porosity • Aquifer boundary	• Easy and inexpensive to apply • Accounts for some local information • Based on simple physical assumptions	Aquifer transmissivity and pumping rate are known and a uniform hydraulic gradient can be estimated; may not be appropriate for fractured bedrock aquifers
• Groundwater flow direction same as topographic slope • Horizontal flow	• Aquifer boundary • Water table contours (or topographic contours) • Geology • Water quality	• Accounts for local information • Physically based • Moderate-expensive to apply • Large data requirement	May be especially useful for shallow, unconfined aquifers, springs, as well as karstic and fractured bedrock aquifers
• Depends on the model	• Aquifer boundary • Geology • Water table elevations • Aquifer transmissivity • Hydraulic conductivity of aquitards • Knowledge of boundary conditions	• Accounts for local information • Physically based • Predictive capability • Moderate-expensive to apply • Large data requirement	Where hydrogeology and groundwater conditions can't be adequately represented by simple analytical models (e.g. bedrock aquifers, complex hydrogeology, vulnerable aquifers or multiple wells)

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Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 3

Identify Potential Contaminants and Assess Risk

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Designing Plans for Source Water Protection in Nova Scotia

A Drinking Water Strategy for Nova Scotia describes a multiple-barrier approach to clean, safe drinking water for Nova Scotians. The first line of defence in this multiple-barrier approach is to keep clean water clean. This booklet series describes how water utilities and municipalities can do that. It guides you through the process of developing a source water protection plan for your municipal water supply.

To keep clean water clean, we must protect the source water supply area. This guide describes **Step Three** in the process recommended by Nova Scotia Environment and Labour (NSEL) for implementing a source water protection plan: Identify potential contaminants and assess risk.

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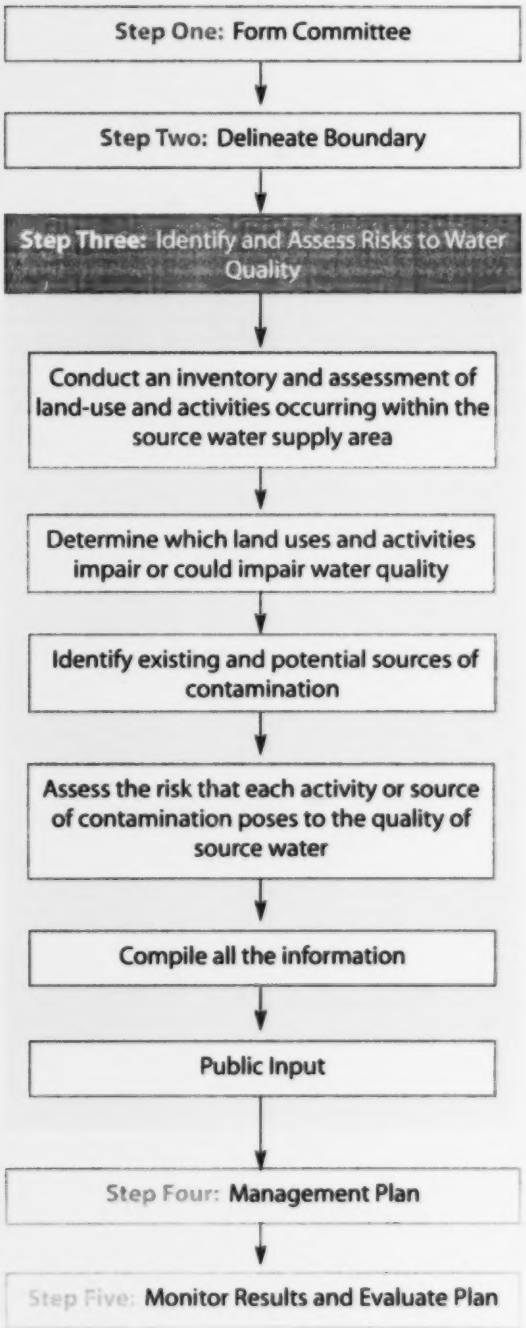
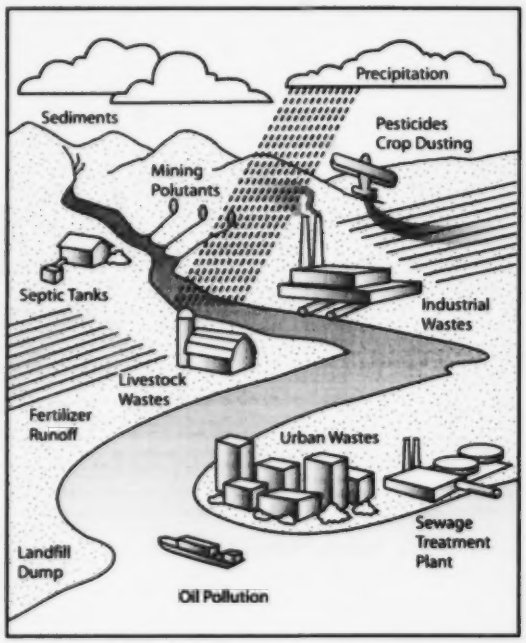
Step Three Flow Chart


Step One: Form Committee
Step Two: Delineate Boundary
Step Three: Identify and Assess Risks to Water Quality
Conduct an inventory and assessment of land-use and activities occurring within the source water supply area
Determine which land uses and activities impair or could impair water quality
Identify existing and potential sources of contamination
Assess the risk that each activity or source of contamination poses to the quality of source water
Compile all the information
Public Input
Step Four: Management Plan
Step Five: Monitor Results and Evaluate Plan

Introduction

Contamination of water occurs when a body of water is adversely affected due to the addition of toxic or sufficient amounts of materials to the water. When it is unfit for its intended use, water is considered to be contaminated. There are two types of water pollutants: point source and non-point source.

Point sources of pollution can, in many instances, be monitored and regulated. Non-point sources are much more difficult to control. Pollution arising from non-point sources accounts for a majority of the contaminants found in water.



This illustration shows the range of pollution that can cause contamination of water resources.

Point Sources
Point sources are contaminants that are released from a specific, known location.

Examples:
- industrial point discharges, as well as leaks of industrial chemicals
- municipal wastewater effluents
- landfill sites
- wastes from existing and abandoned mining sites
- on-site septic systems
- underground storage tanks: chemicals, oil, and gas
- saltwater intrusion

Non-point Sources
Non-point sources of contamination are diffuse in nature. These types of contaminants are difficult to locate, making it hard to identify the source.

Non-point sources of contamination can be transported into drinking water supplies by overland runoff into watercourses or by transport in groundwater to wells.

Examples:
- agricultural activities
- urban runoff from buildings, streets, and sidewalks
- pesticides
- recreational boating
- road salting
- acid rain

Identifying and Assessing Risk

Contaminated water, caused by pollution from either point or non-point sources, can eventually find its way into source water. Contaminated water must be treated before it is distributed for human consumption.

Keeping contaminants from entering source water supply areas is the **first barrier** in the multiple-barrier approach to protecting drinking water quality. Clean water requires less treatment. The types of contamination that present a risk to source water quality fall into several categories. These categories of risk are outlined in the next section.

What Are the Risks to Source Water?
- **Microbial contaminants**, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.

- **Inorganic contaminants**, such as salts and metals, which can occur naturally or result from urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming.

- **Pesticides and herbicides**, which may come from a variety of sources such as agriculture, storm water runoff, and residential uses.

- **Organic chemical contaminants**, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban storm water runoff, and septic systems.

- **Radioactive contaminants**, which can be naturally occurring or be the result of oil and gas production and mining activities.

- **Sediment** is associated with the weathering of soil and rock. Human development can cause sedimentation, primarily through soil erosion. Sediment can seriously harm the quality of source water.

- **Nutrients**, such as nitrates and phosphorus can be generated by human activity, and cause **eutrophication**, whereby excessive plant growth depletes oxygen levels in water.

Conducting An Inventory

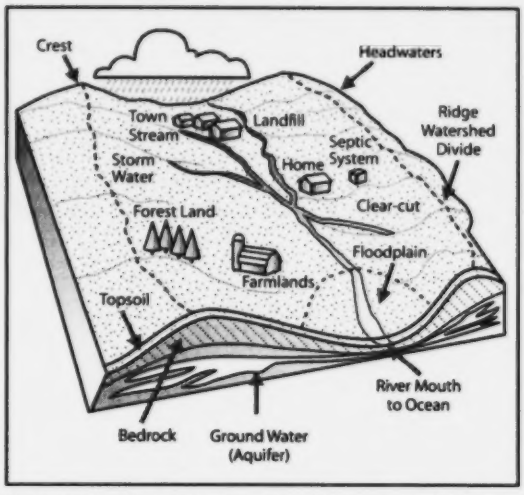
The purpose of **Step Three** is to identify and evaluate risks to source water quality. This is accomplished by identifying activities within your source water supply area that could create contamination.

A methodology can be followed to evaluate the scale of risk posed by activities.

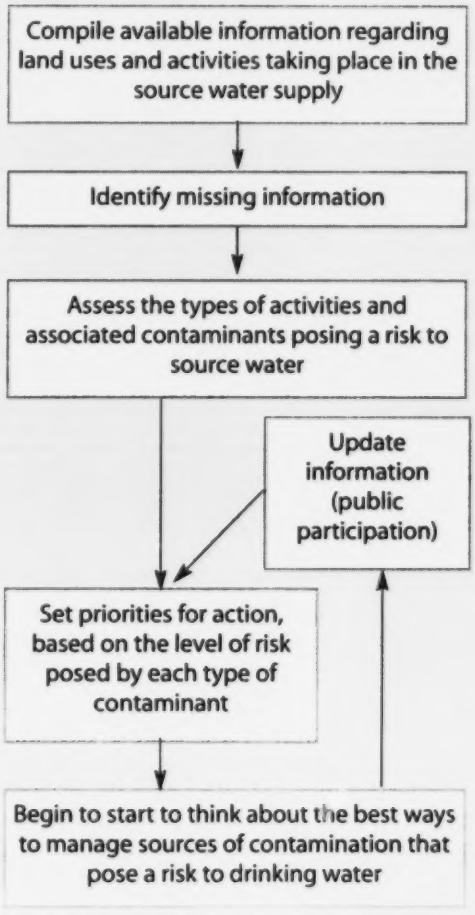
Conducting an inventory of your source water supply area is the best way to identify the types of activities that are associated with contamination. By conducting an inventory of the source water protection area, you will be better able to assess the kinds of risks that need to be addressed through the management plan. An inventory also allows for an evaluation of the scale of risk.

For example, if agriculture only comprises a small fraction of the total area of a source water protection area, then the risk posed by fertilizers, pesticides, and other kinds of agricultural contamination may be minimal. On the other hand, if urban development is predominant, risks associated with urban runoff, chemical and fuel storage, and septic systems, will be priorities.

The next section of this booklet provides some background to conducting an inventory of your source water protection area. There is a wide variety of information available to help you understand the kinds of activities and their related risks to water quality. An inventory can either be very detailed in its analysis, or quite basic, depending on the character of the particular source water supply area. The following section will outline some of the sources of information that can be used to inventory your area.



An inventory of your source water protection area will take into account the types of land uses that characterize the area.


Compile available information regarding land uses and activities taking place in the source water supply
Identify missing information
Assess the types of activities and associated contaminants posing a risk to source water
Update information (public participation)
Set priorities for action, based on the level of risk posed by each type of contaminant
Begin to start to think about the best ways to manage sources of contamination that pose a risk to drinking water

A comprehensive inventory of your source water protection area will lead to a good sense of what kinds of activities are taking place within it.

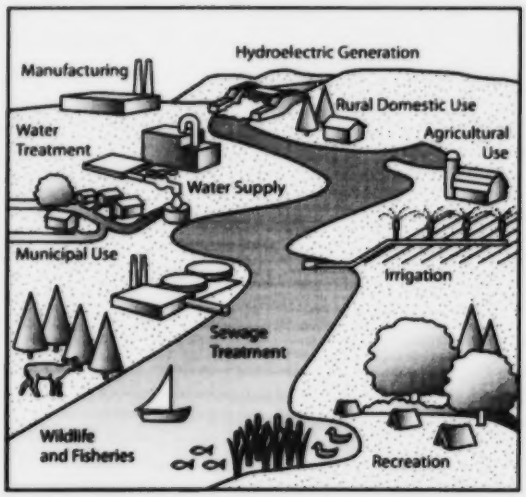
An inventory will allow you to assess the impact of activities occurring within your source water protection area. This approach will help identify activities that are associated with contamination, and consequently pose a risk to the quality of drinking water. The ultimate goal is to produce a management plan (**Step Four**) that recommends ways to avoid or minimize these risks.

Information can be gathered from a variety of sources. We recommend that the inventory begin with a broad look at the source water supply area by examining both the physical and human elements of the area.

Physical Considerations

A good place to begin is with a description of the physical characteristics and conditions within your supply area:

- the size of the source water protection area
- the variety and pattern of land uses (e.g., forestry, agriculture, recreation, urban development, etc)
- the nature of the water source (lake, stream, or groundwater)
- the capacity of the water supply
- the level of water treatment
- known and reasonably suspected concerns about water quality and quantity (e.g., sewage, commercial activity, water withdrawals) and their location
- general resource characteristics (e.g., lands prone to erosion, wetlands, etc.)
- roads and transportation corridors



Common Sources of Water Contamination include:

- *algae growth in surface water, caused by nutrients from agriculture*
- *sedimentation from construction and development*
- *effluent discharges*
- *erosion of bare soil, causing runoff*

Human Population Considerations

Careful accounting of human population considerations such as demographics and population growth trends can also be an important part of the inventory. Population information will help the group to recognize present and future trends in population growth. This will, in turn, affect development and land use activities that may in turn pose a risk to source water. Helpful information can include:

- land ownership patterns
- sub-division activity, size of lots, and development trends
- population characteristics (urban or rural, location of consumers relative to water supply, number of people serviced relative to number of people in the source water supply area, etc)
- demographics (is the population growing or declining? Are growth centres expanding?)
- employers
- number and types of dwellings
- user information (industrial/commercial/domestic)
- existing controls (land-use planning, designation under the *Environment Act*)

Land Uses and their Relative Risk to Source Water

Least risk

1. Land surrounding reservoir/well, owned by water utility/municipality
2. Permanent open space dedicated to passive recreation
3. Woodlands and managed forests

1. Field crops: pasture, hay, grains, vegetables
2. Low-density residential: lots greater than 2 acres
3. Churches, municipal buildings

1. Institutional uses
2. Medium-density residential: 0.5 to 1.0 acre lot sizes
3. Commercial uses with limited hazardous material storage or underground chemical or fuel storage

1. Agricultural production: dairy, livestock, nurseries, orchards,
2. Golf courses, quarries
3. High-density housing: lots smaller than 0.5 acre

1. Retail commercial: gasoline, farm equipment, automotive, dry cleaners, photo labs, machine shops, furniture strippers
2. Industrial: all forms of manufacturing and processing
3. Underground chemical and fuel storage
4. Waste disposal: pits, dumps, ponds, lagoons, landfills

Greatest risk

Compiling Information

Once the range of contamination risks are identified, compile and rank the information according to the relative threat to the water quality. This can be a difficult task, but it should be based upon scientific fact and experience.

Example:
Scale 1 (high) - 5 (low)

- Agriculture is predominant in the source area: there are issues related to nutrients, microbes, and chemicals. It is assigned a high rank (1)
- Urban development is growing: there are issues related to urban runoff and domestic on-site oil tanks. It is assigned an intermediate rank (3)
- Forestry exists on a small scale: there are a few issues related to sedimentation resulting from forest access road construction. It is assigned a lower rank (4)

Based on this type of ranking system, when the management plan is developed (**Step Four**), agriculture will be given a higher priority for management action than forestry.

Encouraging Public Participation

The main intent of **Step Three** is to identify and evaluate issues that pose a threat to the quality of drinking water. At this stage, the utility or municipality — in partnership with the advisory committee — may want to invite the public to contribute to the body of knowledge gathered by the utility. The people and businesses within the source water protection area will know their own activities. They may also know additional sources of contamination or other risks which may pose a threat to water quality. It is beneficial for the utility to invite local stakeholders to an open-house type gathering, in order to collect information from them.

Once activities that are associated with specific kinds of contamination are identified, you can start to think about the most appropriate ways to manage these activities in order to reduce their impact to source water.

Example:

Contamination Issue	Activity/Cause	Scale of Problem*	Priority Rank**
Nutrients	• Agriculture	3	2
Fuel Leaks	• Domestic oil tanks	4	1
Sedimentation	• Construction	1	1
	• Agriculture	2	2
	• Forestry	4	3
Pesticides	• Agriculture	4	2
Bacteria	• Domestic septic systems	2	1
	• Manure	3	2
	• Municipal effluent	3	3
Salt	• Road de-icing	3	4

** 1 = Severe, 3 = Moderate, 5 = Minimal ** 1 = High, 3 = Moderate, 5 = Low*

Public Input: Benefits

- The utility or municipality can promote a clear identification and understanding of the problem and the solutions
- Public participation will help to promote community ownership of the problems and the solutions
- Integrate public feedback into policy decisions and final management implementation.

Final Products

By the end of **Step Three** the utility should have a clear understanding of issues and concerns relevant to the source water supply area. Potential sources of water contamination will be known and ranked according to the risk they pose to the safety of the source water supply.

As a result of **Step Three** of the process, the utility or municipality should have:

- a complete listing of all identified existing and potential issues that pose a risk to drinking water quality
- a list of existing and potential issues prioritized in the order in which they are to be addressed in the management plan

For More Information

Nova Scotia Environment and Labour can review the committee's risk assessment of the source water supply area and provide comments.

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Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 4

Develop a Source Water Protection Management Plan

Step 4

Develop a Source Water Protection Management Plan

Designing Plans for Source Water Protection in Nova Scotia

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To keep clean water clean, we must protect the source water supply area. This guide describes **Step Four** in the process recommended by Nova Scotia Environment and Labour (NSEL) for implementing a source water protection plan: Develop a Source Water Protection Management Plan.

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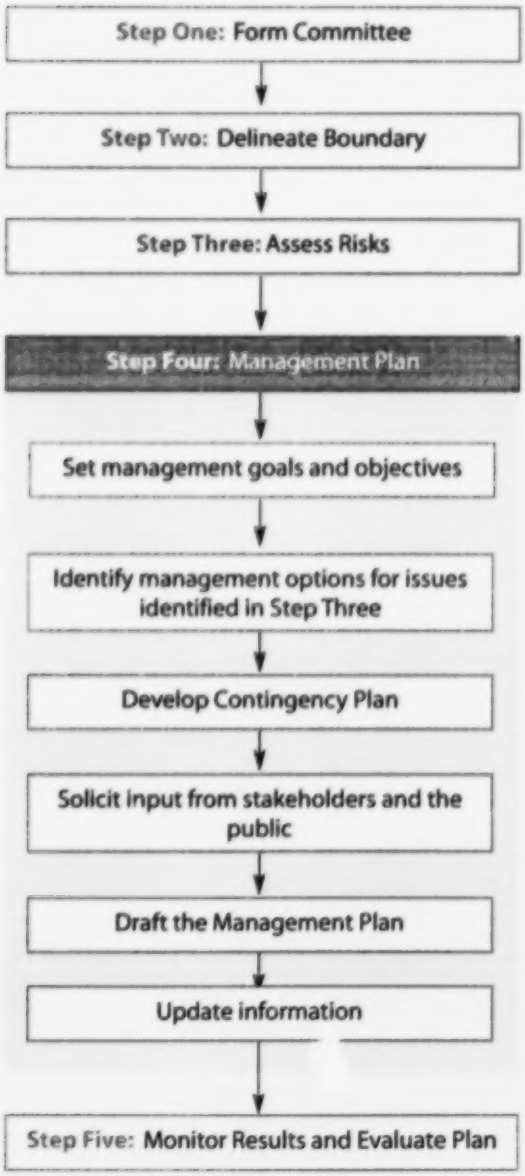
Step Four Flow Chart


Step One: Form Committee
Step Two: Delineate Boundary
Step Three: Assess Risks
Step Four: Management Plan
Set management goals and objectives
Identify management options for issues identified in Step Three
Develop Contingency Plan
Solicit input from stakeholders and the public
Draft the Management Plan
Update information
Step Five: Monitor Results and Evaluate Plan

Introduction

Source water protection is an approach to water-resource management that enables individuals, groups, and institutions with a stake in management outcomes (often called stakeholders) to participate in identifying and addressing local issues that affect local water supply areas.

Source water protection plans should be community-based and involve local stakeholders. This approach results in solutions that respect a community's unique social, economic, and environmental conditions and values. Stakeholder participation also creates a sense of commitment to resolve identified problems and develop solutions, thus ensuring long-term support for resulting management plans.

Almost every activity on the land has the potential to affect the quality of water in a community. Management planning brings together the people within the source water protection area to address those activities, regardless of existing political boundaries. By working together, individuals within the source water protection area can design a coordinated management plan that builds upon the strengths of existing programs and resources, and addresses the water quality concerns in an integrated, cost-effective manner.

Matching management options to issues that affect source water quality (**Step Three**) is a critical step in the development of a source water protection plan. At this stage the advisory committee will focus on developing management options for risks to water quality identified in **Step Three**.

Review: Steps 1 to 3:
A source water protection management plan cannot be developed until **Steps One** to **Three** are complete:

- An Advisory Committee is formed
- The source water protection area is delineated and characterized
- Sources of contamination are identified and addressed
- Source water issues that are currently being addressed have been defined
- Source water issues that will be addressed in the new management plan have been defined
- Source water issues that need to be addressed in the long term have been defined
- Resources and funding have been thoroughly explored

A source water protection plan is not a single strategy, but an approach to water resource protection. The goal of a management plan is to protect the source water supply area while considering the social and economic factors relevant to that area.

By now you should have completed Steps 1, 2 and 3. In **Step One**, the advisory committee is formed. In **Step Two**, the area to be managed is delineated and marked on a map. **Step Three** helps to identify sources of contamination, and demonstrates how to evaluate risks to source water quality within the delineated protection area.

Step Four will focus on the development and implementation of the management plan for the source water supply area. Management plans will be variable; however groundwater supplies generally use a management method that employs wellhead protection zones with management controls that become more stringent the closer the lands are located to the actual wellhead (**Step Two**). Surface water supplies tend to use a broader range of potential management options to protect water quality. A management plan for a surface water supply is often based on controlling activities that could harm the water.

Source Water Protection Management Options

Acquisition of Land: Land acquisition gives direct ownership and control of the source water protection area to the utility or municipality. This is a preferred option because of its obvious benefits. The purchase of land may include all lands within the source water protection area, or may be confined only to land areas that play a critical role in protecting the water source.

Bylaws: Land-use planning through the use of municipal planning strategies and zoning is a very powerful tool to ensure that potential contaminant threats or activities are sited away from the water source. Developing bylaws is subject to mandatory public consultation requirements.

Best Management Practices (BMPs): Once individuals and industries understand they may be part of the problem, they also understand they can be part of the solution. BMPs are a good way to introduce a change in the way businesses, industry and individuals treat the environment.

Preventing drinking water contamination at the source makes:

- Good public health sense
- Good economic sense
- Good environmental sense

Contingency Planning: An emergency response plan provides a blueprint for action in the event of a dangerous contamination occurrence within the source water protection area. All utilities or municipalities must have a contingency plan in place for their source water protection areas.

Designation: Formal designation as a Protected Water Area under Section 106 of the Nova Scotia Environment Act, is a mechanism for utilities or municipalities to develop regulations for activities that have the potential to impair source water quality. Regulations will apply to the source water protection area defined by the utility or municipality and advisory committee. Designation is subject to mandatory public consultation requirements.

Education and Stewardship: Few people will make changes without understanding what changes need to be made, why change is needed, how to make the change, and how the change will affect the individual. Educating people and communities on the importance of source water protection will help introduce a change in behavior and begin a move toward environmental stewardship. Educating the people who live and work within source water protection areas creates a sense of ownership and shared responsibility for the protection of the water resource.

Moving Forward from Step Three to Step Four

To begin Step Four, the advisory committee should have completed (in **Step Three**):

- A list of potential water quality contaminants
- Identified sources of contamination
- Knowledge about pathways of contamination into the water supply
- A ranking of priority water quality issues to address

Example: Tables like those outlined below provide important information that is critical to making management decisions in **Step Four**.

Prioritization of Risk

Contamination	Priority Ranking
Sediments	1
Bacteria	2
Nutrients	3
Hydrological flow	4
Oils, Grease, Metals	5

Ranking: 1 = high priority 5 = low priority

Contamination	Sources	Causes
Nutrients	• Livestock in streams • Failing septic systems	• Uncontrolled access • Improper siting and maintenance
Sediment	• Livestock in streams • Road-stream crossings	• Uncontrolled access • Undersized culverts • Human access
Bacteria	• Livestock in streams • Failing septic systems	• Uncontrolled access • Improperly sited/maintained septic systems
Hydrologic Flow	• Urban storm water	• Paved surfaces, lack of infiltration areas
Oils, Grease and Metals	• Storm drains	• Improper oil disposal, paved surfaces, parking lots

Now you are ready to examine management options and begin to develop the management plan. The management plan should be integrated with existing programs and tailored to the needs of the community and the unique character of the source water protection area. Ideally, multiple programs and solutions will be developed as part of the management plan to provide flexibility in the implementation of the final plan.

Key Elements of a Management Plan

- Clearly defined management objectives
- Range of management options
- Prioritization of management solutions
- Description of rationale and uncertainties
- Cost estimates and funding mechanisms
- Schedule for implementation and completion

The next few pages of this booklet will examine the management options in more detail. Management techniques recommended in **Step Four** are well established and are being used across North America and other parts of the world as practical ways to protect drinking water supplies. It is important to note that these options are only a partial list. Utilities and municipalities are free to develop new innovative or site-specific ideas or options to manage risks to water quality.

Lessons from Walkerton

The tragedy that occurred in Walkerton, Ontario resulted in many recommendations:

"Source water protection plans should be required for all watersheds in Ontario"

Set Management Goals and Objectives

A management plan should begin with a statement of goals and objectives.

For example, the goal of the management plan may be "to protect source water for drinking". Objectives would include statements that relate to the mechanisms the committee will employ to achieve this goal. For example, one objective may be "to reduce and prevent sources of non-point pollution that are known to enter the source water protection area."

What Should The Management Plan Achieve?

A source water protection plan should present a complete picture of the source water supply area. As you assemble your plan, keep in mind that a person with limited knowledge of the source water protection area should be able to read the plan and understand the needs and proposed solutions for effectively managing land uses and activities in the source water protection area.

The final product should be an action-oriented approach for addressing water quality in the source water protection area. The management plan is not static and may change as implementation proceeds. The utility or municipality should work with the advisory committee to review the management plan periodically to ensure that tasks are being implemented and that the plan is updated (see **Step Five**).

A well-written management plan describes how the utility or municipality and community will work together to implement the source water protection plan and meet the goals and objectives for protecting water quality.

Assembling the Plan
The management plan may use a variety of options or strategies to address water quality issues affecting the source water protection area.

The advisory committee needs to carefully consider and evaluate each of these options and others that may be identified to determine the most appropriate ways to protect water quality. This is achieved by examining the benefits and disadvantages of each management option. One of the roles of the advisory committee will be to consider the effect of each management option. This is necessary to properly balance water protection with land uses and economic activity within the source water supply area.

Public Input
Public review or comments may be needed during evaluation of specific management options. This will help to inform the advisory committee about the various effects and acceptability of the management options under consideration. The final recommended management plan should also receive input from the public, and address public concerns, before it is considered to be complete.

Identify Management Options

The ABCs of Source Water Management Planning:

(A)CQUISITION OF LAND
The direct purchase and ownership of land comprising the source water protection area affords one of the highest levels of water quality protection. This is because the utility/municipality can:
a) control the use of the land in the supply area,
b) provide close surveillance of the entire area, and
c) enforce rules and regulations to protect drinking water resources.

Land acquisition can take several forms:
- Purchase of the entire source water protection area
- Acquisition of the most sensitive and critical sites within the source water protection area
- Acquisition of property that may affect water quality (waterfront lots, etc.)
- Acquisition of lands surrounding the water treatment plant intakes

Utilities and municipalities may choose to work with non-profit organizations to acquire land and easements for riparian buffers to protect source water supply areas, or develop a comprehensive land acquisition program of their own. Given the expansion of urban areas across the province, there is a narrowing window of opportunity to take advantage of opportunities to acquire private lands within source water supply areas.

(B)YLAWS

Land-use planning can be an excellent tool for the protection of source water areas, and many water quality benefits can be derived from a successful land-use planning strategy.

A Municipal Planning Strategy (MPS) allows a municipality to develop land-use bylaws (LUB) that manage development. These bylaws can be geared toward the protection of drinking water supplies. Existing planning strategies and bylaws can be amended to reflect changes designed to protect source water, or in cases where no planning strategy exists, a MPS and LUB can be developed, specifically with water quality in mind. In either case, land-use planning techniques must be developed in conjunction with municipal planners.

A variety of land-use planning techniques can be used to manage land use in source water protection areas. Some of these include:

- Limit the number of lots
- Provide separation from watercourses
- Impose erosion and sediment controls during construction
- Require vegetation for sediment and erosion control
- Limit permitted uses
- Require large lot sizes

The basic objective of involving land-use planning as a part of a source water protection plan is to manage new development and protect sensitive areas within the source water supply area.

More information regarding land-use planning in source water supply areas can be found in the Service Nova Scotia and Municipal Relations Local Government Resource Handbook: *Municipal Water Supply Watershed Planning Model - Section 5.7.* http://www.gov.ns.ca/snsmr/muns/manuals/mga.stm

The process for adopting or amending a municipal planning strategy is subject to public consultation.

(B)EST MANAGEMENT PRACTICES (BMPs)

Best Management Practices: (Also known as "BMPs") Common-sense actions to keep soil and other pollutants out of streams and lakes. BMPs are designed to protect water quality and to prevent pollution.

Best Management Practices for source water protection areas are those that are determined to be the most effective and practical known means of preventing or reducing the amount of pollution. The underlying philosophy is to conduct everyday activities in an ecologically sound manner in order to keep pollutants out of source water. This is generally cheaper and more practical than removing them later. All stakeholders can use BMPs to direct land use activities and protect water quality.

BMPs have been developed for most industries and sectors of the economy. Many can be used as guidelines for conducting business or everyday activities in ways that protect to water. A best management practice can be found for almost every activity that may occur within a given source water protection area. The forestry and agriculture sectors have developed BMPs for activities that can affect water quality, in addition to BMPs that have been developed for a wide range of large and small-scale commercial activities. BMPs are also developed to reduce sources of urban pollution like storm water runoff.

A source water protection plan that uses BMPs as the primary mechanism for protecting water quality should work closely with stakeholders within the source water protection area to implement the most appropriate BMPs.

In addition to BMPs published by the Nova Scotia government, there are numerous other sources of information on this subject. The United States Environmental Protection Agency (EPA) has developed a wide range of BMPs for industries and activities within source water protection areas. Many of these can be applied to land-based activities in Nova Scotia. Managers of water supplies can take advantage of the large body of existing material associated with BMPs and drinking water, to encourage good management practices by stakeholders within a source water protection area. More information can be found at the following web link: http://www.epa.gov/safewater/protect/swpbull.html

Best Management Practices (BMPs) currently exist for many kinds of activities that could harm water quality:

Residential/Homeowners

1. On-site Sewage Disposal (Septic Systems)
2. A Homeowners Guide to Oil Tank Safety
3. Home Garden Pest Control
4. Composting Yard Trimmings and Leaves (Waste Reduction Fact Sheet)
5. Sustainable Gardening
6. Pollution Prevention: At Work and at Home
7. Preserving Shorelines

- http://www.gov.ns.ca/enla/water/index.htm
- http://www.gov.ns.ca/enla/rmep/p2/ipmfact.htm
- http://www.gov.ns.ca/enla/pubs/pubtype.htm
- http://www.extension.umn.edu/distribution/naturalresources/components/DD6946a.html

Commercial Activities

1. Gas Stations: Best Practices*
2. Pollution Prevention Guide for Printers in Atlantic Canada*
3. Pollution Prevention Guide to the Management of Dental Waste*
4. Environmental Checklist for Businesses*
5. Developing Environmental Policy*
6. Composting Facility Guidelines
7. Golf Course Environmental Self Assessment Manual For Golf Course Superintendents*
8. Pollution Prevention: A Discussion Paper

* Forthcoming web links will be available at: http://www.gov.ns.ca/enla/services.htm

- http://www.epa.gov/owow/nps/urbanmm/index.html
- http://www.gov.ns.ca/enla/pubs/pubtype.htm

Forestry

1. Constructing Forest Access Roads
2. The Forest Professional - Guidelines for the Stewards of Tomorrow's Forests (2nd Ed.)

- http://www.gov.ns.ca/natr/publications/forpubs.htm
- http://www.gov.ns.ca/enla/pubs/pubtype.htm
- http://www.epa.gov/owow/nps/forestrymgmt/
- http://www.chesapeakebay.net/pubs/subcommittee/nsc/forest/handbook.htm

Agriculture

1. Manure Management Guidelines
2. Stream Bank Protection Brochure
3. Stream Crossings Guidelines
5. Milkhouse Wastes Guidelines
6. Environmental Farm Plan Program
7. Soil Conservation Program
8. Recommended Agricultural Practices within Municipal Drinking Water Supplies in Nova Scotia (Draft)

- http://www.gov.ns.ca/nsaf/home.htm
- http://www.epa.gov/owow/nps/agmm/index.html
- http://www.gov.ns.ca/nsaf/rs/envman/onfarm/index.htm
- http://www.usawaterquality.org/newengland/focus_areas/ag_bmps/default.html
- http://www.agr.gc.ca/pfra/water/agribtm_e.htm

Recreation

1. Waterfront Recreation BMPs
2. Boating Stewardship

- http://www.epa.gov/owow/nps/mmsp/index.html
- http://www.extension.umn.edu/distribution/naturalresources/components/DD6946e.html

Developers/Construction

1. Erosion and Sediment Control Handbook for Construction Sites
2. Construction & Demolition Debris Disposal Site Guidelines

- http://www.gov.ns.ca/enla/pubs/pubtype.htm#other
- http://www.mrsc.org/subjects/environment/water/SW-BMP.aspx?r=1

(C)ONTINGENCY PLANS

The goal of a contingency plan is the immediate and long-term protection of the source water supply area.

A contingency plan will identify personnel, testing equipment, procedures, and materials which can be used for the rapid correction or mitigation of environmental accidents which might constitute a water supply emergency. A contingency plan should also include response protocols, notification procedures and methods of containment. Accidents which might directly affect the source water protection area also need to be addressed with methods for isolating portions of the water supply and/or providing water from an alternative source.

A water supply emergency may range in severity from a power outage to the effects of a widespread natural disaster. For the purposes of source water protection, the most probable threat requiring an emergency response will be from a hazardous substance spill within the source water supply area. Such a spill may occur at a fixed location involving the handling or storage of chemicals. It could result from a transportation accident. No matter what the cause, once it is contaminated your source water supply may never be recoverable. A contingency plan is critical.

Water Supply Information

Emergency responders may or may not know a lot about the source water supply area. The contingency plan needs to make sure there are ways of telling them the:

- location and capacity of all surface water sources/wells and storage tanks
- location and size of all major distribution lines (Distribution Map)
- critical locations of isolating valves for the distribution system
- options available for providing an alternative water supply
- location and capacity of water treatment facilities

Alternative Water Supply Options

Your contingency plan should consider how to provide water from an alternate source. If a water supply emergency occurs, system operators need to be able to quickly provide uncontaminated water to any portion of the distribution system.

Generally, there are five means of managing a water supply. Contingency planners should consider:

1. Reducing water use: Where additional capacity is not available, restricting water use may be a viable alternative. Applying this approach requires effective communications with water users to obtain a reduction in water use.

2. Supplying water from within the system: An alternative water source may be available within the system through isolation of the affected area and providing water from wells and/or portions of the distribution system unaffected by the water supply emergency. This option requires a thorough understanding of the distribution system dynamics and prior development of additional capacity generally at a different location.

3. Providing bottled water: Can be an option for some customers affected by a drinking water emergency.

4. Supplying water from outside the system: This is generally accomplished by connection to an adjacent drinking water supply.

5. Treat affected source water: A method may be made available to provide treatment to the affected source water by removing contaminants to an acceptable level.

Contents of the Contingency Plan

A contingency plan is required as part of a utility's operations program. The contingency plan should include as a minimum:

- General procedures for routine emergencies or major emergencies within a water supply area
- A procedure for equipment becoming inoperable in a major emergency and/or due to power failure
- A procedure for dealing with spills or releases
- A boil water advisory procedure*.
- Facility-specific information on the hazardous material stored or transported in the source water area.
- Provision for annual review and update by the utility.

* A utility must ensure that drinking water meets the bacteriological requirements set out in the *"Guidelines for Monitoring Public Drinking Water Supplies"* published by NSEL, and available on line at: http://www.gov.ns.ca/enla/pubs/dw_gui.PDF. These guidelines outline procedures for reporting and correcting deficiencies in quality due to microbiological contamination of drinking water.

(D) ESIGNATION

Section 106 of the Environment Act allows the Minister of Environment and Labour to designate an area surrounding a drinking water source as a Protected Water Area (PWA), provided certain requirements are met. The Environment Act specifies that designation will be put into place only when a formal request is received from the municipality or water works operator, and sufficient public consultation has occurred.

Designation involves developing regulations that are specific to the PWA. Regulations control activities that are known to harm water quality in the source water protection area. A complete designation consists of a description of area to be protected and the regulations required to control or prohibit activities or development that may harm water quality in the designated area. The development of regulations is based on consensus among committee members, and involves open communication among the committee, the utility or municipality, stakeholders, and the local community.

The following outlines the designation requirements contained in Section 106, Environment Act, chapter 1, S.N.S, 1994-95.

Designation of protected water area
106 (1) The Minister, when requested by an operator of a water works or proposed water works, may designate an area surrounding any source or future source of water supply for a water works as a protected water area.

Notice of designation
(2) The operator of a water works or proposed water works named in a designation made pursuant to subsection (1) shall

(a) give notice of the designation of the area as a protected water area by publishing the notice in a newspaper having circulation in the county or counties in which the area is located and in the Royal Gazette;

(b) have the notice of designation recorded at the registry of deeds and the land registration office in the county or counties in which the area is located; and

(c) post signs in the area indicating that it has been designated a protected water area.

Responsibility of operator
(3) The operator of a water works or proposed water works is responsible for taking all measures to protect the area designated, and the enforcement of any regulations made pursuant to subsection (6).

Designation Checklist
Here's a summary of how to designate a Protected Water Supply area under the Environment Act:

- ❑ Form an advisory committee consisting of landowners and other stakeholders affected by the designation process (**Step One**).
- ❑ Gather information on the source water supply area. This information should include: the watershed boundary, variety and pattern of land uses, land ownership patterns, sources of contamination and other information that will assist in decisions regarding the development of regulations for the proposed designation (**Steps Two, Three**, and **Four**).
- ❑ The utility or municipality in conjunction with the advisory committee identifies issues and concerns; then develops a draft management plan for the proposed Protect Water Area, including public information materials. The advisory committee helps ensure appropriate public consultations.
- ❑ Send the description of the Protected Water Area, proposed regulations and a summary of the public consultation to NSEL for review and comment.
- ❑ Formal designation as a Protected Water Area by the Minister occurs after:
  a) the regulations are found to be acceptable to the water utility or municipality, the advisory committee and NSEL;
  b) there has been sufficient public consultation, and
  c) the documents are reviewed by a NSEL solicitor representing the Province.
- ❑ Designation takes effect when filed with the Provincial Registrar of Regulations and published in the Royal Gazette.
- ❑ The utility or municipality should also have notice of the designation recorded at the Registry of Deeds, and published in local newspapers.
- ❑ The water utility or municipality is responsible for posting signs to clearly identify the boundary of the Protected Water Area and indicate that regulations are in effect for the designated drinking water supply.

Cancellation
(4) When requested by an operator of a water works or proposed water works, the Minister may cancel a designation made pursuant to this Section, in whole or in part.

Designation continues
(5) Any protected water area designated pursuant to the Water Act, prior to the coming into force of this Act remains so designated.

Regulations
(6) At the request of the operator of the water works or proposed water works, the Minister may make regulations to prohibit, regulate or require the doing of any act or acts in a protected water area that may impair or prevent the impairment, as the case may be, of the quality of the water in the protected water area.

Public consultation
(7) Before designating a protected water area, the Minister shall ensure that the operator of the water works or proposed water works has provided opportunities for public consultation.

Claim for injurious affection prohibited
(8) No claim for injurious affection lies against any person as the result of a designation of a protected water area.

Once the designation is completed, the utility or municipality is responsible for administering the regulations within the PWA.

(E)ducation and Stewardship

Source water protection can also be achieved through an education and stewardship program developed and promoted by the utility or municipality.

Management plans based on education and stewardship promote ideas and information related to source water, water quality, water pollution issues, and strategies to protect water resources. They promote cooperative relationships between stakeholders and the broader community. They are based on the mutual benefits to the community and the water supply. It requires strong public support.

In order to make a management plan based on education and stewardship effective, the utility or municipality should begin consulting with the community right from the start. This builds trust, support and understanding for the plan. If it proceeds too far before the public is informed, there may be problems with rumours and the spreading of misinformation.

There are many ways for utilities or municipalities to promote a stewardship approach to source water protection in their community. Submitting information to community newspapers at the start of the campaign, for example, will help spread information.

However, it's important that key community people and stakeholders are well informed prior to any development of the management approach. Whenever possible, provide a contact name and information about any upcoming activities related to stewardship programs being promoted. People are often motivated to ask questions or provide input after they learn about the proposed plan through fact sheets, brochures, community papers and other sources of local information.

A source water protection plan that uses an education and stewardship approach will greatly benefit from partnerships with local environmental organizations and other Non-Government Organizations (NGOs) at the community level. Organizations dedicated to clean river projects, adopt-a-river, and other types of water-related stewardship programs, can provide an established network for promoting source water protection. Watershed clubs are also becoming more common across Nova Scotia, and local watershed clubs can be a valuable source of support for source water management plans that promote education and stewardship.

Solicit Input

Building support

Knowing your community is critical to building support for successful source water protection plans. One of the first steps in building grass roots support is to identify the individuals and organizations in the community who will be affected by the source water protection plan. Inviting the public to express its views and concerns about the plan can help to enhance community support and ultimately the success of the project. If the community doesn't support your source water protection plan as proposed, stand back and try to be objective.

- Have you provided enough information?
- Has the advisory committee used the comments it sought?

It is important to take advice from the community, and then let people know where their input has made a difference. This will empower the community to help set priorities, define issues and find solutions.

Informing the public

Open houses offer a way to spread information and educate the public about the importance of source water protection. An open house allows the public to learn more about water quality issues and management approaches to reducing impacts to water quality. An open house provides an opportunity for people to briefly express their concerns or support. It is important to ensure opportunities to provide written or oral input for people unable to attend. Ideally an open house is held at a local community hall where people can come and go at their leisure during designated hours.

Provide take-home materials to reinforce the water utility's message. If displays are being used to provide information, knowledgeable people should always staff them. Open houses can be used successfully at various stages of the project.

Semi-permanent displays at libraries or other public gathering places may also help educate the public about water quality issues that affect them at the community level, as well as introduce the concept of environmental stewardship. It is best to use the same materials as those displayed at open houses or create similar displays using more durable materials, so that messages and ideas are reinforced. Posting information about the water utility and the services it provides on an Internet site can give additional community support as well as wider coverage.

Consider whether public forums may be a useful way to educate the public, especially once the community is aware a source water management plan is being developed. A public forum allows for meaningful, in-depth dialogue and gives participants the opportunity to voice concerns about the project and provide input regarding alternatives. Water utilities may want to consider having a professional facilitator chair the forum and design a process for clarifying issues and exploring stewardship options.

A printed fact sheet outlining the management plan as proposed, including public benefits, is also a good way to convey information. It is best to make the fact sheet short and easy to read. Fact sheets can be distributed to the public via the mail, household drop-offs, grocery bag-stuffers, newspaper inserts or other appropriate methods. Encourage comments, questions and suggestions.

Draft The Management Plan

Management plans are specific to each individual source water supply area because they are based on the type of water supply and also on the land-use activities that surround the area. However, the elements that comprise the management plan are the same for all source water protection plans and include:

1. Introduction
- Delineation of the area for protection
- Background to conditions in the source water area
- The need for management
- The process of management plan preparation
- Terms of reference for the advisory committee
- Time frames

2. Water Quality Issues
- Activities within the source water supply area
- Potential sources of contamination
- Pathways of contamination
- Prioritization of issues based on risk
- Summary of issues

3. Goal and Objectives
- A statement of what the plan is meant to achieve
- Management practices that have been evaluated for effectiveness, cost, maintenance, useful life, adverse effects and public acceptability

4. Management Recommendations
- Options to address issues
- Proposed integration of management options
- Contingency plans
- Items for immediate action

5. Implementation
- Policies, action steps and guidelines on how the watershed management plan will be implemented.
- A schedule outlining time lines for implementation with details regarding resources needed, and the contact persons or agencies.
- A program to solicit public awareness and interest in water protection.
- Strategy for evaluating and updating the management plan.

The management plan should be reviewed regularly in order to assess the effects of activities within the source water protection area their effects on water quality and to assess whether changes are needed. The keys to success are communication and willingness to modify the plan when new information is available.

Final Product

The final management plan should include:
- A statement of the management objective(s)
- List of risks to water quality to be addressed in the plan
- List of evaluated management methods to be employed to protect water
- An implementation strategy for each management option with time frames
- Contingency plan for emergencies to source water
- Strategy for evaluation and updating of the management plan

For More Information

Nova Scotia Environment and Labour can provide input into the development of management practices and will review the final source water *protection plan.*

Nova Scotia Environment and Labour
Water and Wastewater Branch
5151 Terminal Road
PO Box 697,
Halifax, Nova Scotia
B3J 2T8

Phone (902) 424-5300
Fax (902) 424-0503
Web address: www.gov.ns.ca/enla/

Service Nova Scotia & Municipal Relations
Municipal Services Division
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Environment and Labour

Developing a Municipal Source Water Protection Plan: A Guide for Water Utilities and Municipalities

Step 5

Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan

Step 5

Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan

Designing Plans for Source Water Protection in Nova Scotia

A Drinking Water Strategy For Nova Scotia describes a multiple-barrier approach to clean, safe drinking water for Nova Scotians. The first line of defence in this multiple-barrier approach is to keep clean water clean. This booklet series describes how water utilities and municipalities can do that. It guides you through the process of developing a source water protection plan for your municipal water supply.

To keep clean water clean, we must protect the source water supply area. This guide describes **Step Five** in the process recommended by Nova Scotia Environment and Labour (NSEL) for developing a source water protection plan: Develop a Monitoring Program to Evaluate the Effectiveness of a Source Water Protection Plan.

The results of carrying out **Step Five** may warrant review and modification of information developed in **Step Four**. The monitoring and evaluation plan is an effective way to determine whether or not the management plan is working properly or if any changes need to be made to it. The intensity of sampling, which means the number of locations and frequency of sample collection, depends upon the existing or potential contaminant sources identified in **Step Three** and the budget of the utility or municipality. The utility or municipality will have to weigh the benefits of investing in new equipment and collecting additional data against the added costs.

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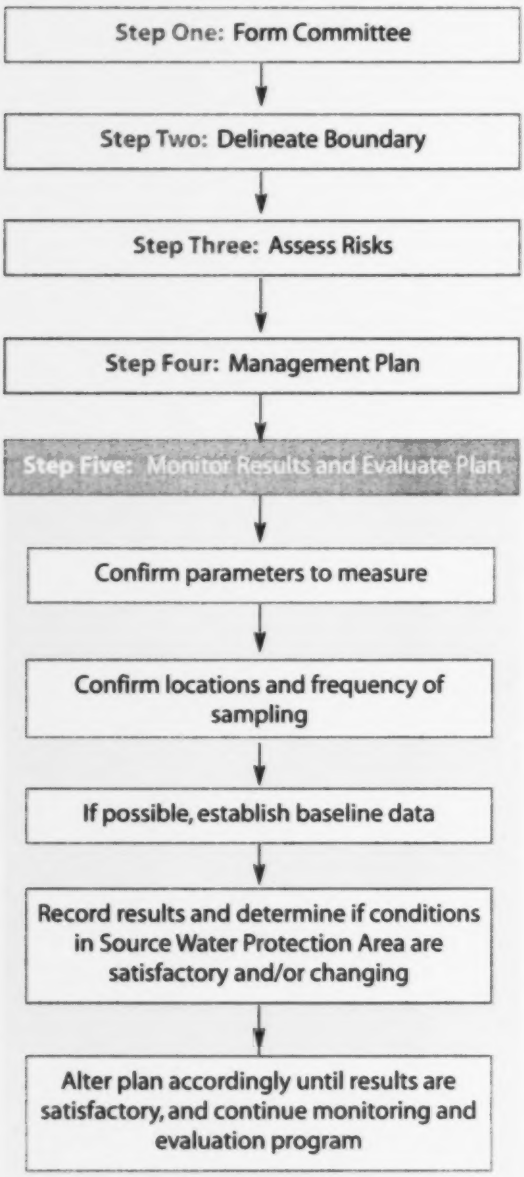
Appendix: Lake Water Quality Monitoring Example 6

Step Five Flow Chart


Step One: Form Committee
Step Two: Delineate Boundary
Step Three: Assess Risks
Step Four: Management Plan
Step Five: Monitor Results and Evaluate Plan
Confirm parameters to measure
Confirm locations and frequency of sampling
If possible, establish baseline data
Record results and determine if conditions in Source Water Protection Area are satisfactory and/or changing
Alter plan accordingly until results are satisfactory, and continue monitoring and evaluation program

Introduction

A formalized review process should be put in place to monitor the performance of the Source Water Protection (SWP) Plan formed in **Step Four**, and to ensure that the plan is regularly updated if it is not meeting its objectives. The plan may not be meeting its objectives if water quality is deteriorating in the SWP Area or the management options (such as best management practices) identified in **Step Four** are not being followed. A municipality or utility should be able to link deterioration in water quality to one or more of the risks identified in **Step Three**.

The water quality monitoring associated with this program should be designed to evaluate changes in the state or health of the SWP Area. This complements, but is different from the monitoring completed by a utility or municipality on its raw water to meet regulatory requirements. Raw water quality monitoring may be on a much more frequent basis depending on the source of supply, risk of contamination, type of treatment and similar factors.

The monitoring and evaluation program for the SWP Plan will help assure the municipality or utility that the plan remains current with changing conditions and priorities in the Source Water Protection (SWP) Area. Monitoring is the responsibility of the utility or municipality.

In addition to monitoring the SWP Area through water quality and quantity sampling, municipalities should also undertake visual monitoring of their SWP Area. For example, regular inspections of the area (a drive-by or walk-through) can identify potential water quality problems, such as all-terrain vehicles in watercourses. Surveys and discussions with local residents and business operators can reveal if they are following the Best Management Practices defined in **Step Four**. This may help determine if additional education efforts are required, identify problems that are not being adequately addressed, or may identify activities that are in violation of the bylaws or regulations that have been put in place to protect water quality.

The advisory committee should review the evaluation of changes in source water quality and quantity, as well as the success of management options and the need to improve the plan. The following contains information on each of the recommended actions for **Step Five**.

Confirm Parameters to be Measured

As part of the Protection Plan, potential and existing sources of contamination were identified in **Step Three**. The Monitoring Program should be set up so that it monitors parameters that will act as indicators for these sources of contamination. For example, if one of the potential sources of contamination is a gravel road, then the program should measure turbidity or suspended solids.

There is more information about monitoring parameters in the appendix. The number and types of parameters measured will depend on the risks posed to source water and the budget for the monitoring program.

Hints for Monitoring Groundwater:
If you are monitoring groundwater, consider partnerships with private well owners to incorporate existing wells into the monitoring network.

You should monitor the Wellhead Protection Area (WHPA) zones based on the type of substances that each zone is designed to manage. Consider the following options and tailor the program to site specific sources of contamination:

- Zone 1 - monitor for bacteria regularly, and periodically monitor general chemistry, metals, pesticides, chlorinated solvents and Total Petroleum Hydrocarbons (TPH) and benzene, toluene, ethyl benzene, xylene (BTEX)
- Zone 2 - monitor for BTEX, TPH, pesticides, chlorinated solvents, general chemistry, and metals every 2 to 5 years
- Zone 3 - monitor for pesticides, chlorinated solvents, general chemistry and metals every 5 to 25 years.

Confirm Locations and Frequency of Sampling

Try to collect data at various strategic locations during different periods of the year. The more intensive the program, the more clearly the utility or municipality will be able to detect any changes caused by activities taking place in the SWP Area. This information can also be used to determine the source of contamination.

Surface Water Hint:
Sample during periods of varying hydrological conditions (e.g. periods of low flow, after large rainfall events, during spring melt, etc.).

The selection of sampling locations depends on the characteristics of the SWP Area and any existing or potential contamination. The frequency of sampling will also depend on the amount of money available. If a utility or municipality is on a very limited budget, it should focus its monitoring in sensitive areas and on parameters that give an overall indication of the health of a SWP Area. These include low-cost tests like pH, conductivity, turbidity and coliforms.

Use the information gathered in **Steps Two** and **Three** to determine the appropriate sampling locations and frequency of sampling. NSEL can provide guidance on this. You may also wish to retain qualified professional consultants if you require detailed analysis of your SWP Area.

Raw or untreated water samples taken as part of the utility's regular testing program can be used as part of the Source Water Monitoring Program. The Source Water Monitoring Program should be part of the utility or municipality's overall monitoring program to ensure raw water quality is not deteriorating, and to establish any necessary early warning systems for treatment changes.

Management Hint:
To determine if recommended land-use practices are being implemented, compare the actual practices against the recommended ones.

Establish Baseline Data

Baseline data allow you to determine if your water quality and quantity monitoring results represent a change in the status or health of your source water area. Think of it this way, if you went to the doctor today and they measured your blood pressure you would not know if your health was the same, better or worse than it was a year ago, unless you had taken your blood pressure last year. It would be ideal to have up to three years of data collected before making any modifications to the protection plan. If this is not possible a minimum of one year of data is recommended.

Sampling frequency should be based on the characterization of the source water supply area, sources of contamination, level of risk, etc. The baseline data can then be used to determine if water quality and quantity conditions are improving, remaining stable or deteriorating. Therefore, it is very important to collect as much relevant data as possible during the initial stages of the monitoring program so that a strong understanding of the baseline conditions is established, before any changes in the SWP Area occur (e.g. an increase in development).

Sampling Protocol

To provide consistent, representative, and comparable samples for analysis and data for interpretation, any monitoring program must follow protocols established in accordance with standard accepted methods. Sampling protocols are established in the latest edition of Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association, American Water Works Association and the Water Pollution Controls Federation (can be ordered on-line from bookstores at www.awwa.org or by telephone at 1-800-926-7337). Another useful reference document is The Inspector's Field Sampling Manual, latest edition, written by Environment Canada (can be purchased on-line at: http://www.ec.gc.ca; or by calling 1-800-734-3232). Useful information is also presented in the Appendix of this document. These examples may be used to develop standard operating procedures specifically designed for your utility.

It is important to understand the objective of the program and the parameters of concern because sampling protocols may vary. For example, sample filtering may be necessary in the field or special preservation methods may be needed. To ensure you have the correct sampling equipment (bottles, etc.) check your sampling requirements at least two weeks before you plan to sample. Also check with an accredited laboratory regarding any special needs that they may have.

Groundwater Monitoring Hint: Water utilities or municipalities should include a description of sampling procedures and protocols in the monitoring and evaluation plan. For groundwater, that includes how the well will be purged (e.g. 3 to 5 well volumes to remove stagnant water). The standard operating procedures should also include information on cleaning and maintaining sampling equipment as well as any calibration requirements. A monitoring program should have written Quality Assurance/Quality Control (QA/QC) protocol to go along with the sampling program.

This may include field, spiked and blind duplicate sampling procedures as well as documenting how the QA/QC sample will be evaluated and could potentially include corrective and additional sampling requirements if the sampling program does not meet the QA/QC objectives.

Record Results and Determine if Conditions Are Satisfactory and/ or Changing

After a year or more (preferably 3 years) of baseline data collection you can begin to determine if any patterns are present. Statistical analysis can be conducted on the data to better illustrate any patterns. Graphing the data and results of the statistical analysis are good ways to visualize the results.

Example:

Surface Water Monitoring You may have three years of Total Nitrate baseline measurements that show increasing levels in the summer followed by decreasing levels in the late fall and into the winter. You can now compare any new results with this baseline data to determine if any significant changes are taking place.

For example, in the future you may record higher than normal Total Nitrate levels in the summer. This large change indicates the possibility of increased nutrients being released in your SWP Area.

A statistical analysis could be used to determine if the changes are significant. If they are, you may wish to examine your SWP Area for potential causes of this change and modify management options if necessary.

Monitoring Hint: You should consider the costs of the monitoring program - capital (wells or equipment) and operational (sampling and analysis), before developing it. The utility or municipality will have to weigh the benefits of investing in new equipment and collecting additional data against the added costs.

Alter Protection Plan Accordingly Until Results Are Satisfactory, and Continue Monitoring and Evaluation Program

If the results of your Monitoring Plan indicate the quality of water in your SWP Area is not satisfactory or is changing significantly, you should re-examine your Protection Plan to determine a suitable course of action. Similarly, if certain components of your SWP Plan are not being adhered to (e.g. best management practices are not being followed) then you should evaluate the situation and determine how to improve it (e.g. conduct more education or put in bylaws). It is possible that the actions you have put in place (whether it be bylaws, land acquisition, etc.) may need to be altered to better fit the current state of your SWP Area. This is especially true as more and more time passes since you developed your Protection Plan.

For example, when a Protection Plan was first developed there may not have been any large forestry operations in the SWP Area. The municipality may have allowed the clear-cutting of land, as long as it was separated from streams by 20 metres. However, over time the intensity of forestry has increased, and this management option is no longer appropriate for the amount of trees being cut. Therefore, after re-examination of the issues and a determination that the large amount of forestry has resulted in an increase in turbidity, the Advisory Committee could work with forestry stakeholders to increase the buffer width for watercourses from 20 metres to 40 metres, and to manage the percentage of the SWP Area that is harvested.

Special attention should be paid to future water quality results if any changes are made to the Protection Plan due to the results of the Monitoring Plan. It is important to determine if the changes have produced the desired improvement in water quality. If the water quality does not improve, the Protection Plan should be re-evaluated, and this should continue until the problem is solved. The Monitoring Plan should be reviewed annually and updated every 5 years.

Using Water Quantity Measurements to Aid in Evaluation of the Protection Plan

Although it is most important to measure water *quality*, a water *quantity* monitoring program can provide useful information on the health of your SWP Area. For example, if the volume of water in your SWP Area decreases significantly, such as during a drought or due to large withdrawals by a business, then the risk of high contaminant levels in your raw water may increase. Think of it this way, if a package of juice crystals is added to a jug of water it tastes pretty good, but if you add the same amount of crystals to a small glass of water it tastes pretty bad! The more water you have in your SWP Area, the lower the risk of a given volume of contaminant causing problems for your treatment system.

As part of a water quantity monitoring program you could collect precipitation data from a nearby airport and measure the source water levels each week, or in your well(s) each month or quarterly, or use data loggers. Again, the more information collected, the more confident you can be in your results.

Final Products

The water utility or municipality should develop a monitoring and evaluation plan that helps them to determine:

- how well their source water protection plan is being implemented
- how well it is protecting their water quality and quantity

For More Information

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Appendix

LAKE WATER QUALITY MONITORING EXAMPLE

Example of Field Protocol
Field Protocol for Water Sampling of Lake

1. Less than an inch (< 25mm) of precipitation in the previous 24 hours is a prerequisite for any regular monthly sampling, but not for sampling intended to follow large rainfall events.

2. Safety should be considered of primary importance. Therefore, sampling alone or under windy or rough conditions is not recommended.

3. Using a contour map and sounding line locate sampling station which is to be located at the deepest location on the lake. Then lower anchor slowly. Care must be taken when taking soundings and when anchoring boat so that bottom sediments will not be disturbed and thereby contaminate water samples.

4. After anchoring boat, determine depth to bottom with sounding line once again and record on data sheet. Then determine transparency using a standard 8 inch black and white Secchi disk as per the standard methodology (Davies-Colley et al (1993)).

5. Determine air and surface water temperature with hand-held thermometer and record.

6. Record weather conditions as required on field data sheet.

7. Dissolved oxygen and temperature profiles will be determined at the deepest station of each lake using a YSI or similar meter.

8. Determine and record dissolved oxygen and temperature profiles using field meter if available. Alternatively, determine through sample collection and hand-held thermometer. If conductivity and/or pH meters are available, field measurements of these parameters should be undertaken.

9. Water samples are to be collected and preserved in a manner consistent with procedures outlined in *Standard Methods for the Examination of Water and Wastewater*, APHA, latest edition. These samples are to be taken at the deepest station on each lake at the surface (i.e. 0.5 meter depth), bottom (i.e. 1+ meters above bottom), and at the thermocline if present.

10. Two 500 ml water samples are to be taken at the surface, while one 500 ml sample at each of the bottom and thermocline locations will suffice.

11. *Standard Methods for the Examination of Water and Wastewater* should be consulted for specifics, but the following outlines the general procedures:

    a) Label sample bottles clearly with date, name of person taking samples, and location as per the following example for Loon Lake:
    - LL - DS1 - 0m
    - Where: LL = lake name (i.e. first initials)
    - DS1= station number (i.e. deep station #1)
    - 0m = depth from surface where sample was taken [0m indicates a surface sample, but sample should actually be taken at 0.5 meters so as to avoid any film of materials at the air / water interface]

    Water samples are to be taken at the following depths if no thermal stratification is evident:
    - 0.5 meter depth (surface).

    If thermal stratification is observed, samples are to be taken at the following additional depths:
    - 1 meter from bottom (bottom),
    - at the depth where temperature drops > 1 degree C in 1 m depth (thermocline)
    - at a depth which equals twice the Secchi depth (euphotic zone) for chlorophyll a analysis only.

    Note: If twice the Secchi disk depth is greater than the deepest lake location, take an additional sample at 1 meter off bottom for chlorophyll analysis.

Sample preservation is to be assured by immediately placing in cool, dark storage until analysis at lab. No fixatives are required to be added in the field.

b) Avoid contamination of sample bottle and water sampler by keeping closed and preferably stored in cooler or case until ready for taking of sample.

c) Thoroughly rinse sample bottles and caps with lake water (avoiding surface layer) at least three times before use.

d) Avoid contact with bottom sediments, surface scums, gasoline, oil, insect repellant, sun block, cigarette smoke, soap, etc. to prevent fouling of sample.

e) Using clean bottles obtained from certified analytical laboratory, fill bottles completely to the top of the neck.

12. Samples are to be shipped to a laboratory approved for chemistry testing (see http://www.gov.ns.ca/enla/water/labs.htm for a list of accredited laboratories), and samples should reach the lab within 24 hours of collection.

13. Analyses for all samples are to include the parameters in the monitoring plan. Note: Be sure to check the detection limit provided by the lab, as this may impact your analysis.

Sample Form to be Submitted to Laboratory

ANALYSIS REQUISITION

Report and Bill to:
Water Utility or Town Engineer

Copy to:
Municipal Engineer

Client's Phone Number:
Fax Number:

Sample Name (ID):
(ie LAKE - STATION# -DEPTH)

Sample Location:

Date and Time (24-Hr clock) Taken:

Collected By:

List of individual or group tests requested:

Analyses for **all samples** are to include: (example only)
- Colour, turbidity, pH, sodium, potassium, chloride, sulphate, alkalinity, magnesium
- Metals analysis
- Lowest level analysis of nutrients (to 0.001 mg/l detection limit)
- TP
- TN

Additional analytes for the **surface samples** (marked 0m or surface) are to include: (example only)
- Chlorophyll a
- TSS

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